CHAPTER 2. HISTORY OF THE SACRAMENTO AND SAN JOAQUIN RIVER BASINS

GENERAL OVERVIEW

The great Central Valley of California contains the two largest rivers in the State, the Sacramento River in the north and the San Joaquin River in the south. These river systems comprise a combined drainage area of over 41,000 square miles.

Such a vast watershed demanded, with a growing population, a water supply system, flood protection system, hydropower generation, navigation network, and a means whereby to harness the most valuable resource in the State - namely, water - into economic growth.

From the middle of the nineteenth century to the middle of the twentieth century, engineers, geologists, farmers, and citizens cooperated to achieve the goals of protecting and developing farmland, protecting cities from floods, providing agricultural irrigation, as well as municipal and industrial water supplies, and building a network for navigation. Miners also competed with these groups for water use, until hydraulic mining was outlawed in the late 1800's.

Historically, the Sacramento River basin has been subject to floods that result from winter and spring rainfall as well as combined rainfall and snowmelt. The San Joaquin River basin has been subject to floods that result from both rainfall that occurs during late fall and winter months, and unseasonable and rapid melting of the winter snowpack during the spring and early summer months. The effectiveness of the flood management systems along the rivers has been affected over time by natural processes and by man-made structures. For example, the flood management system along the complex (in some areas multi-channel) San Joaquin River and its tributaries continues to be impacted by reductions in floodway channel capacity caused by sediment deposition. Bank erosion is another problem, but on a much smaller scale than in the Sacramento River.

Public policy has also changed, and lessons have been learned regarding the most effective approach to wise long-term flood and related environmental resource management. The most recent lesson was given by the flooding of 1997, which exposed many of the sizing, structural, operational, land development, and institutional problems within the present flood management system, a system that was originally envisioned early in this century. In addition to the flooding concerns that have continued to grow over the past several decades, environmental resource concerns in the watershed have also been recognized by the public. The need to restore these environmental resources has been identified within the State as one of the Central Valley's major goals.

This chapter describes the physical conditions of the Sacramento and San Joaquin River basins and how they have changed historically in response to the development by Californians of the State's water resources.

PHYSICAL GEOGRAPHY

The Central Valley is a product of sedimentation processes. Deposition in old inland seas, from glacial activity, and of sediment transported by the many rivers and streams draining the surrounding mountains have deposited gravel, sand, silt, and clay thousands of feet deep. Agricultural production in the valleys is dependent on only the uppermost few feet of the most recent deposits.

The Sacramento and San Joaquin Rivers drain the Central Valley, and join together in the Delta to flow to the San Francisco Bay, then to the Pacific Ocean. This distinct drainage area was created by geologic processes acting on various rock types over millions of years. The area is called the Central Valley Province, one of eleven that are present at least partly in the State.

The Central Valley geologic province is composed of tertiary sediments and volcanics, and is a northwest-trending asymmetric trough 400 miles long and averaging 50 miles wide. It is bound on the west by the pre-Tertiary and Tertiary semi-consolidated to consolidated marine sedimentary rocks of the Coast Range. The faulted and folded sediments of the Coast Range extend eastward beneath most of the Central Valley. The east side of the valley is underlain by pre-Tertiary igneous and metamorphic rocks of the Sierra Nevada.

Pre-Tertiary marine sediments account for about 5 miles of the total amount of sediments deposited in the sea before the rise of the Coast Range. Marine deposits continued to fill the Sacramento Valley until the Miocene Epoch, and filled portions of the San Joaquin Valley until the late Pliocene, when the last seas receded from the valley. Continental alluvial deposits from the Coast Range and the Sierra Nevada then began to collect in the newly formed valley. The Sacramento and San Joaquin valleys are filled with as much as 10 and 6 vertical miles of sediment, respectively.

The valley floor is divided into several geomorphic land types which include dissected uplands, low alluvial fans and plains, river floodplains and channels, and overflow lands and lake bottoms. The dissected uplands consist of consolidated and unconsolidated continental deposits of Tertiary and Quaternary that have been slightly folded and faulted.

The alluvial fans and plains consist of unconsolidated continental deposits that extend from the edges of the valleys toward the valley floor. The alluvial plains cover most of the valley floor and make up some of the highly developed agricultural lands in the Central Valley. Alluvial fans along the Sierra Nevada consist of high percentages of clean, well-sorted gravel and sand.

Fans from Coast Range streams are less extensive. West side fans tend to be poorly sorted and contain high percentages of fine sand, silt, and clay. Interfan areas between major alluvial fans of the east side are drained by smaller intermittent streams similar to those in the west side.

Thus, they tend to be poorly sorted and have lower permeabilities than main fan areas. In general, alluvial sediments of the western and southern parts of the Central Valley tend to have lower permeability than east side deposits.

River floodplains and channels lie along the major rivers and, to a lesser extent, along the smaller streams that drain into the valley from the surrounding Coast Range and Sierra Nevada. Some floodplains are well-defined where rivers are incised into their alluvial fans. These deposits tend to be coarse and sandy in the channels and finer and silty in the floodplains.

Several secondary geologic structures are found within the Central Valley. The Red Bluff Arch in the northern end of the Sacramento Valley consists of a series of northeast-trending anticlines and synclines, which act as a groundwater barrier between the Sacramento Valley and the Redding Basin. East of Colusa in the central part of the Sacramento Valley, the Sutter Buttes rise 2,000 feet above the valley floor. The Sutter Buttes are a remnant of a volcanic cone 10 miles in diameter.

In the San Joaquin Valley, a faulted ridge known as the Stockton Arch extends from the Sierra Nevada to the northern Diablo Range. Along the west side of the San Joaquin Valley, the faulting and folding of the adjacent Coast Range are present in the Central Valley in the Kettleman Hills, Elk Hills, Lost Hills, and Buena Vista Hills.

HYDROLOGY, GEOMORPHOLOGY, AND VEGETATION

The hydrology of the Sacramento and San Joaquin River basins is diverse and complex. Precipitation varies dramatically throughout the basins, ranging from up to 80 inches annually over the headwaters of the northern rivers to as little as 8 inches in the Firebaugh-Mendota area. Patterns and rates of runoff and streamflow also vary widely; runoff patterns reflect rainfall, snowmelt, and combined rainfall-snowmelt runoff peaks, and flow rates reflect attenuation and conveyance by dams, reservoirs, and channels. What is known about the hydrology of the basins has been learned from historic geomorphic and vegetative conditions reflected in the landscape and from precipitation and flow rates recorded during hydrologic events.

In general, the Sacramento and San Joaquin Rivers and tributaries that drain the Central Valley flow from the Sierra Nevada and Coast Range mountains, traverse these ranges in high gradient channels cut into steep canyons, cross the foothills, and emerge onto the floor of the valley. As the channel gradient decreases, the floodplains widen.

Specifically, there are some significant differences between the Sacramento and San Joaquin River basins. The next two sections of the report provide an overview of the hydrologic, geomorphic, and vegetative conditions of the Sacramento and San Joaquin River basins, respectively. Following sections present the history of water resource development in the basins and describe the changes in the basins from the 1820's when ownership of the region passed from Spain to Mexico, to California's claim to the land, to the present time.

THE SACRAMENTO RIVER BASIN

Originating in the Klamath Mountains at the northern end of the valley near Mt. Shasta, the Sacramento River is joined by the McCloud River and the Pit River in what is now Shasta Lake, a reservoir created by Shasta Dam. The eastern side of the valley is drained by several rivers and large streams that flow from the western slopes of the Sierra Nevada. The major tributaries-Feather, Yuba, Bear, and American Rivers-and many minor tributaries (Butte, Big Chico, Cow, Deer, and Battle Creeks) flow into the Sacramento River along its way south from Shasta Lake to the Delta. On the western side of the valley, Cottonwood Creek is the largest unregulated tributary to the Sacramento River. The presence of smaller streams such as Clear Creek, Elder Creek, Thomes Creek, Stony Creek, Cache Creek, and Putah Creek reflects the drier climate of the western edge of the Sacramento River basin.

Rivers in the Sacramento Valley historically had maximum flows from December through April, as a result of substantial rainfall in the winter and early spring. Snowmelt maintained flow during the spring and early summer, and summer drought resulted in low flows through late fall.

Flood flows carrying sediment in the Sacramento River and the other major rivers and streams in the Sacramento Valley created natural levees that separated the rivers from adjacent flood basins. The Butte, Colusa, Sutter, American, Sacramento, and Yolo Basins received large volumes of flood flows from both the mainstem of the Sacramento River and from the tributary rivers and streams. Not all tributary flows from the surrounding mountains therefore reached the Sacramento River. Flows from streams such as Putah, Cache, and Butte Creeks, as well as overflow from the Sacramento River, often ended in these sinks that once consisted of tule marsh.

The inundation and hydrologic importance of the natural flood basins of the Sacramento Valley were reflected in reports on floods of the late 1800's and early 1900's:

> *During the high water of March 1879, the low lands of the Sacramento Valley, to the extent of about 847 square miles, were covered with water; this area includes all flooded for a short period of time, as well as that upon which the water rested for several months. Above the mouth of the Feather River, in what may be called the upper flood region, the area covered was about 483 square miles; and below that point, in what is called the lower flood region, the flooded area was about 364 square miles in extent.* (W.H. Hall, in "Report of the State Engineer to Legislature of California," 1880)

> *The lateral basins affected the channel characters in several ways. They conveyed a large part of the flood discharge and thus left for adjacent portions of the channel only a small part. They acted as reservoirs for the storage of floodwaters and fed them gradually to the lower course of the Sacramento, so that the channels in the delta region were only moderately taxed by the floods. The channels in consequence were adjusted for conveyance of only a fraction of the flood discharge; they were of moderate section and their meanders were of small radius. Between the town of Colusa and the mouth of the Feather River, the Sacramento River grows gradually smaller downstream until its estimated capacity is only 10 percent of flood discharge.* (G.K. Gilbert, "Hydraulic Mining Debris in the Sierra Nevada," U.S. Geological Survey, 1917)

The geomorphology of the Sacramento River, which drains about 27,000 square miles, varies throughout the basin. From the base of Mount Shasta (north of the city of Redding) for about 75 miles downstream to about elevation 300 (near Red Bluff; River Mile 243), the river is generally restrained from moving laterally by erosion-resistant volcanic and sedimentary formations. The river in this reach, the Sacramento Canyon, is generally narrow and deep, and the floodplain is similarly narrow. From here, the river emerges onto the broad alluvial floodplain of the Sacramento Valley.

For the next 50 river miles or so, the Sacramento River freely meandered across a wide floodplain. By eroding and depositing sediment, the river migrated through deep alluvial soils from the Red Bluff area to the area about where Hamilton City and Chico Landing are located, River Mile 194.

At River Mile 190, Stony Creek joins from the west and flows from Big Chico Creek approach from the east at River Mile 193. From this point downstream, flood flows along the Sacramento River were split between the mainstem and the adjacent flood basins that were separated from the mainstem by natural levees. Because of the natural geomorphic processes associated with valley basins such as the Sacramento, the size and capacity of the mainstem decreased in the downstream direction. The sheer magnitude of flood flows resulted in several distributary flood paths across the flat valley floor into which mainstem flows spilled. The existing flood management system of the Sacramento River, described in detail later in this chapter, was generally designed to accommodate this natural pattern of flood flow, with some modifications that have adapted the system to water and land uses since the late 1800's.

Riparian resources also reflect and affect geomorphic processes and provide valuable habitat for many fish and wildlife species. Riparian vegetation consists of the plant community that exists within the river channel and on the channel margins.

Plant species that make up the riparian community tend to be adapted to the changing physical environment that characterizes a fluvial system. Although the formation of fluvial landforms (bars, floodplains, and terraces) which are related to distinctive hydrogeomorphic processes (flow durations, and flood frequency, intensity, and timing) are largely independent of vegetation, once established, vegetation is an integral part of the fluvial system. Riparian vegetation can affect sediment deposition, channel stability, and channel dynamics.

The most common riparian plant species in the Central Valley include cottonwoods, willows, alders, sycamore, and valley oak. These and other plant species provide habitat for numerous fish, reptiles, amphibians, birds, mammals, and invertebrates. Riparian habitat, and the diversity of riparian plant succession processes that are associated with the geomorphic processes of meandering rivers, provide vegetation that is vital for diverse and abundant wildlife. Rich bird life in particular characterizes riparian habitats. Riparian habitat supports many smaller birds, mammals, reptiles, and amphibians, which in turn are prey to larger vertebrates.

Around the mid-1800's, the mainstem of the Sacramento River was bordered by an estimated one-half million to one million acres of riparian vegetation, described as green and dense riparian forests of oaks, sycamores, and cottonwoods. G.H. Mendell described in 1875 the vegetative conditions, and their potential effects on navigation, of the Sacramento River:

> *Starting from the mouth of the Feather, and going up the Sacramento, we have for about 100 miles as pretty a river as one could desire to see. The water is clear and deep, the current is moderate, being two to three miles an hour, and the banks are permanent and overgrown with vegetation. In this section of the river the regimen is fixed, and beyond the removal of a few snags, which have probably come from the upper river, nothing is required, and nothing can be done to improve the navigation. The river in this section has a nearly uniform width of something between 350 and 400 feet.*
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> *This favorable aspect changes when we pass Colusa, on our upward journey. We here enter upon a section with a larger fall and increased current, a tortuous channel, encumbered with snags, and vexed with bars and rapids. The banks no longer present the same degree of permanence, and the river changes its course at will, eating away the soil at bends and carrying it below to form bars and islands where deposited. The falling banks carry with them the large trees which they support, and thus form clusters of snags, which are the more troublesome, in that they generally occupy the fairway of the river.* ("Examination of Sacramento River Below Tehama and of Feather River Below Marysville, California; Annual Report Upon the Improvements of Rivers and Harbors in California")

Riparian vegetation was widespread throughout the Sacramento River floodplain; dense bands up to five miles wide existed along the mainstem of the river. The habitats that were flooded frequently supported a diverse mix of plant communities along the river, oxbow lakes, sloughs, and other backwaters that supported emergent and submerged aquatic vegetation.

An important feature of riparian habitat is the interface between water and woody riparian vegetation called Shaded Riverine Aquatic (SRA) cover. SRA cover includes overhanging branches, submerged roots, and irregular crevices and surfaces of natural banks. These features provide shade, cover, and food supply to the immediate nearshore environment of large rivers, benefitting fish and wildlife species such as salmonids, river otter, beavers, herons, egrets, and kingfisher.

Land use changes since the era of the California Gold Rush have reduced the extent of riparian vegetation. The State of California and the FWS have estimated that only about one to two percent of the original amount of riparian vegetation exists today. In 1992, in recognition of the scarcity and value of SRA cover, the FWS determined this habitat to be Resource Category 1, defined as being unique and irreplaceable.

THE SAN JOAQUIN RIVER BASIN

The San Joaquin River basin is drained by its principal stream, the San Joaquin River, and by the major tributaries that flow from the Sierra Nevada range on the east side of the basin, the Coast Range on the west side, and the Tulare Lake basin on the south side. East side tributary streams include Cosumnes River, Mokelumne River, Calaveras River, Littlejohns Creek, Stanislaus River, Tuolumne River, Merced River, Bear Creek, Owens Creek, Chowchilla River, Fresno River, and Dry Creek. Many of these rivers on the east side of the basin now have dams and reservoirs on them. West side tributaries include Del Puerto Creek, Orestimba Creek, and Los Banos Creek. The San Joaquin River basin and the Tulare Lake basin are hydrologically connected through the Fresno Slough. Historically, the Tulare Lakebed would collect waters from the Kings, Kaweah, Tule, and Kern Rivers. When the Tulare Lake exceeded capacity, water would overflow north into the Fresno Slough and make its way to the San Joaquin River. Presently, during flood flows, portions of the Kings River flows are diverted north to the Fresno slough and into the San Joaquin River. The San Joaquin River flows through the Delta, and joins the Sacramento River at the upper end of Suisun Bay.

The tributaries that drain the west and south edges of the basin have historically been intermittent, due to the very arid nature of the Coast Range and the Tehachapi Mountains. Maximum flow in the San Joaquin River and its east side tributaries historically occurred in May and June, and was primarily the result of snowmelt. Flows in the San Joaquin River historically peaked at much less than the maximum flow of the Sacramento River into the Delta and earlier in the year. Total unimpaired runoff volume of the San Joaquin River basin system was about one-third of the volume of the Sacramento River basin.

Natural levees were less prevalent along the San Joaquin River and tributaries (which drains about 14,000 square miles of the Central Valley) than along the Sacramento River because of the smaller flows, and lower sediment transport capability, in the San Joaquin River basin. For the most part, natural levees formed primarily along the major rivers in the northern end of the San Joaquin River basin: the northern San Joaquin and the Stanislaus, Tuolumne, and Merced. Sediment was deposited, and minimal natural levees were formed in the southern reaches of the San Joaquin River mainstem only where it entered the valley. No additional flow was added to the mainstem from here to Fresno Slough as no surface water tributaries entered in this reach. The surface flood flows from Fresno Slough were empty of sediment as they had dropped out in the Tulare sub-basin. The other major source of flows in the mainstem--groundwater flow from the Tulare aquifer--was also empty of sediment as they were filtered out by the ground.

As the mainstem of the San Joaquin flowed north over the flat valley floor, it lost its bed load and continued with a reduced sediment load to deposit to form levees and it did not have enough energy to pick up and transport sediment downstream. The river therefore spread out and fed the many large freshwater wetlands of the valley floor. Only downstream of the confluence with the Merced River did the San Joaquin River carry enough sediment to create natural levees in a few places.

Most of the San Joaquin River and tributaries flood management system (described in detail later in this chapter) was developed by the late 1960's. Historically, the San Joaquin River basin has been subject to floods that result from both rainfall that occurs during late fall and winter months and unseasonable and rapid melting of the winter snowpack during the spring and early summer months. The complex San Joaquin River flood management and water supply systems have regulated and reduced flows in the mainstem and in the Stanislaus, Tuolumne, Merced, Chowchilla, and Fresno tributary rivers; high snowmelt peak flows have been reduced and summer low flows have been augmented, significantly changing the pre-settlement hydrology as well as the riparian system.

Less information is available concerning the estimated extent (pre-settlement) of riparian resources in the San Joaquin River basin than in the Sacramento, although some estimates indicate a total of 130,000 acres may have existed along the San Joaquin River, the Calaveras River, and the Tuolumne River. Other estimates indicate that significant resources existed along the Stanislaus and Merced rivers, as well. Additional estimates of the historical extent of riparian forests (including oak woodlands) in the San Joaquin Valley range from about 250,000 acres to about 950,000 acres. The most recent estimate of the historical extent of riparian forest in the San Joaquin Valley is about 400,000 acres. The decline of these resources has matched that of the resources in the Sacramento River basin.

Only about eight to ten percent of riparian forests in the San Joaquin Valley still remain; most were converted to agricultural land. At present, urbanization (especially along the San

Joaquin River), recreational development, aggregate mining, and road construction are stressors, in addition to continuing agricultural encroachment in the floodplain, to the remaining riparian vegetation.

Riparian vegetation downstream of Friant Dam, Mendota Pool and Sack Dam consists of remnant native forested and scrub-shrub wetlands, and is restricted to a narrow band along the San Joaquin River channel. Limited areas of remnant stands remain along some intermittent tributaries along the rivers and in some of the larger sloughs. Some of these areas are periodically burned or cleared. Dominant riparian plant species include cottonwood, California sycamore, and valley oak.

HISTORY OF WATER RESOURCE DEVELOPMENT IN THE CENTRAL VALLEY

THE CENTRAL VALLEY PROJECT

The Central Valley Project was developed to transfer excess water from the Sacramento River watershed, which receives two-thirds to three-quarters of northern California's precipitation, to the much-drier tracts in the San Joaquin River watershed, which collects only one-third to one-quarter of the region's precipitation. The State of California planned such a project for years before approaching the Federal government for assistance. The Bureau of Reclamation and the Corps each made proposals to construct the facilities of the Central Valley Project.

Planning for the inter-basin water transfer was prompted to maximize Californian agricultural output, and this planning began as early as the 1870's. Immediately after California became a state in 1850, the first State Legislature enacted laws to manage water. The Legislature adopted riparian water rights from English Common Law. Owners of land bordering rivers or bodies of water had a right to a reasonable amount of that water. Since these landowners were the only ones who had rights to any of the water, the laws severely restricted the number of landowners who had access to California's water supply.

State water planning became the responsibility of the State Engineer's office, which was created in 1878. William Hamilton Hall, the first State Engineer, attempted the first study of water problems of the State, but in 1889 the Legislature temporarily abolished his position. In 1887, the Legislature passed the Wright Act, which created irrigation districts. Because of problems implementing the act, it was amended in 1897 to stop the establishment of irrigation districts until the Irrigation Districts Bond Certification Commission was formed.

During this time, the Federal government became interested in water in California, as the discovery of gold in 1848 brought Americans from all across the country into the area. Lt. Colonel B.S. Alexander reported to President Grant the results of his 1873 study of the

Sacramento and San Joaquin Rivers, which proposed a system of canals to exchange water from the Sacramento Valley to the San Joaquin Valley.

In 1911, California created The Reclamation Board and authorized the development of a flood management project for the Central Valley. At this time, the U.S. Reclamation Service (later to become the Bureau of Reclamation) and The Reclamation Board began to study water storage possibilities on the Sacramento River. In 1919, Colonel Robert Bradford Marshall, Chief Geographer for the U.S. Geological Survey (USGS), proposed a Sacramento River reservoir storage and water transfer plan to California Governor William Stephens. Because of this plan, Colonel Marshall became known as "The Father of the Central Valley Project."

In 1921, the State saw a need for a more comprehensive water plan to provide for conservation, flood damage reduction, storage, distribution, and uses for all State water. Between 1920 and 1932, at least ten reports were completed to describe water flow, drought conditions, flood management, salinity control, and irrigation issues in the State. The reports were used by State Engineer Edward Hyatt to create the State Water Plan. In 1933, the State Legislature authorized construction of the proposed project as a State project, funded by the sale of bonds of up to a total of $170 million. Additional funds were needed, however, and the State applied to the Federal Emergency Administration of Public Works (FEA) for grants and loans, and thereby created the Water Project Authority. Citing national economic benefits to navigation and flood damage reduction on the Sacramento River, the U.S. House of Representatives' Committee on Rivers and Harbors recommended Federal funding for construction of Shasta (then called Kennett) Dam. The recommended water plan was approved and recommended by the California Joint Federal-State Water Resources Commission, the U.S. Senate Committee on Irrigation and Reclamation, the Bureau of Reclamation, and the Corps.

California amended its application to the FEA in 1934, making effective the Water Project Authority. In September 1935, President Roosevelt issued an executive funding allocation under the Emergency Relief Appropriation Act, for construction of the Central Valley Project. A feasibility report on the project was completed and sent to the President in November 1935; he approved the Central Valley Project, including Kennett (Shasta), Friant, and Contra Costa (Delta) Divisions, in December 1935. The Rivers and Harbors Act of 1937 re-authorized the Central Valley Project, listing as first priorities of the project the improvement of navigation, regulation, and flood control of the Sacramento and San Joaquin Rivers. Reclamation's primary purpose, supplying water for irrigation and domestic use, followed these priorities; power generation was the last priority.

Construction of the Central Valley Project began in the late 1930's. After World War II, however, controversy over the project started. Several issues arose, including State vs. Federal operation and control, public vs. private distribution of power, and Department of the Army vs. Reclamation construction of multi-purpose projects. The issues were discussed at the California Water Conference of 1945. The Central Valley Project continued through the late 1940's and

1950's. Based solely on economic feasibility, the Federal government authorized new divisions of the project, which, by the end of the 1960's, became a conglomeration of various Federal and State governmental agencies. The Corps, for example, constructed several dams in California under the Flood Control Act of 1944, several of which became integrated into the CVP.

The Corps completed construction of Folsom Dam in 1956, then turned operation and maintenance over to the Bureau of Reclamation. In the 1960's and 1970's, more Corps projects were integrated by Congress into the CVP. The Corps continued to construct projects to reduce flood damage. Reclamation contracted for surplus water in Corps-operated facilities for irrigation.

The age of environmental concerns began in the 1970's. In 1973, President Richard M. Nixon signed the Endangered Species Act, which set criteria for listing endangered species and protecting them from harm by Federal agencies or private interests. The Central Valley Project was impacted by the act because of effects of project features on migratory salmon.

The population of winter-run Chinook salmon peaked in 1969, numbering about 118,000 at Red Bluff Diversion Dam. After 1969, populations of salmon and steelhead trout at the dam steadily declined. By 1990, the salmon population dropped to less than 5 percent of their 1969 total. Environmentalists and commercial fishermen called for action.

In 1992, President Bush signed the Central Valley Improvement Act (CVPIA) as part of the Reclamation Projects Authorization and Adjustment Act of 1992, over the objections of California Governor Wilson and Central Valley legislators. The act was considered beneficial by environmentalists, and detrimental by California agricultural leaders. The CVPIA reallocated 800,000 acre-feet (600,000 acre-feet in dry years) of CVP water from Valley farmers to fisheries restoration. CVPIA limited renewed agricultural water contracts to twenty-five years with no long-term renewals.

The Central Valley Project is the largest project by Reclamation; the CVP encompasses thirty-five counties in an area about 500 miles long and 60 to 100 miles wide. Some of the largest dams in the country are part of the CVP.

The Central Valley Project covers three-quarters of the irrigated land in California, and one-sixth of the irrigated land in the United States. Annual farm production in the Central Valley exceeds the total value of all the gold mined in California since 1848. In addition, between 1950 and 1991, the CVP reservoirs prevented more than $5 billion dollars in flood damage.

THE STATE WATER PROJECT

The California State Water Project (SWP) has a delivery system that includes 29 reservoirs and lakes, 18 pumping plants, 4 pumping-generating plants; 5 hydroelectric power plants, and about 660 miles of aqueducts, pipelines, and canals. The SWP is operated by DWR.

Construction of the Oroville Dam project on the Feather River, proposed by the 1957 State Water Plan, marked the inauguration of the SWP. The SWP, designed and constructed by DWR, was built using funds provided by a $1.75 billion bond issue approved by California voters in 1960. By 1973, the initial facilities were completed and water delivery to southern California began.

Unlike the CVP, which only requires the repayment of irrigation projects, the SWP requires water users to pay all project costs. According to the Water Education Foundation, in 1994, the SWP consisted of 22 dams and reservoirs and the North Bay, South Bay, and California Aqueducts. Approximately 30 percent of the water supplied by the SWP irrigates the San Joaquin Valley, while the other 70 percent provides water for residential, municipal, and industrial use, mostly in southern California.

The main purpose of the SWP is to store water and distribute it to 29 urban and agricultural water suppliers in Northern California, the San Francisco Bay Area, the San Joaquin Valley, and Southern California. It provides supplemental water to approximately 20 million Californians and to about 1.2 million acres of farmland. The SWP makes deliveries to two-thirds of the State's population. The project is also operated to improve water quality in the Delta, control Feather River flood waters, provide recreation, and enhance fish and wildlife resources.

THE FLOOD MANAGEMENT SYSTEMS

The flood management systems in the Sacramento and San Joaquin River basins were developed in support of, and in response to, public safety and economic development. Lessons learned from floods over the last century have significantly influenced the evolution of flood management systems. The physical components, as well as the operations, of the systems reflect 50 to 80 years of experience with numerous floods and their very different hydrologic conditions. The systems' basic infrastructure was constructed prior to 1970, in response to the history of flooding and the development of the floodplains up to that time. The flood management systems have performed well to protect the public and the State's economic resources. The river systems must now be managed comprehensively to include protection of environmental and water quality. Following are descriptions of the histories of development of the Sacramento River and San Joaquin River flood management systems.

The Sacramento River Flood Management System

Flood management on the Sacramento River began in the 1850's in response to the necessity to reclaim floodplain land for agriculture. On the condition of reclamation, the Federal government transferred ownership of floodplain lands to the State. The State in turn transferred ownership to private parties with the same condition. Initial construction of levees did not consider the hydraulic effects on other areas or on the natural geomorphic processes of the rivers. With areas of the floodplain cut off from the river by manmade levees, flood flows greatly exceeded the capacity of the resulting channel in many areas. Floods during the 1850's and 1860's resulted in widespread flooding, including the repeated inundation of the city of Sacramento.

Hydraulic mining between 1853 and 1884 exacerbated the flooding problems by adding great amounts of sediment and debris to the flood flows. During this period, millions of tons of silt, sand, and gravel were deposited in stream ways; the beds of the Sacramento, Feather, Yuba, Bear, and American Rivers were raised as much as 20 feet in some reaches. In the 1870's, shipping on the main waterways almost stopped, and adjacent agricultural land was covered with mining debris. In 1884, virtually all hydraulic mining was stopped by court order. By 1900, the State and Federal governments recognized the urgency for a valley-wide flood management system. The Corps' California Debris Commission was created in 1893 to regulate hydraulic mining, improve navigation, and control floodwaters in the Central Valley. The basis for the current system, the Sacramento River Flood Control Project, was subsequently created.

Sacramento River Flood Control Project. The major project for flood management in the Sacramento Valley is the Sacramento River Flood Control Project, which was based on a plan developed by the California Debris Commission in 1910 and authorized by Congress in the 1917 Flood Control Act . Construction began in 1918 on this local cooperation flood control project sponsored by The Reclamation Board of California, which was created by the State Legislature in 1911 at the same time it adopted the plan. It was the first flood control work Federally authorized for construction outside the Mississippi River Valley.

Prior to creation of the California Debris Commission, much thought was devoted to the flood and navigation conditions of the Sacramento River and its tributaries. A system of reservoirs for the partial control of floods was considered as early as 1880, but abandoned as impractical. A system of storage projects primarily for irrigation was also considered, along with channel modification plans, natural and leveed bypass plans, and various combinations of these plans. The proposal that incorporated the leveed bypass concept became the basis of the present project. Reservoirs were recommended, but their construction was to be deferred until the multipurpose projects were feasible. Most of these reservoirs have been built. The existing project is described in more detail in Chapter 4 and in the Post Flood Assessment.

Sacramento River and Major and Minor Tributaries Flood Control Project. This project was authorized by Congress in the 1944 and 1950 Flood Control Acts and first funded in 1948. Its improvements on the Sacramento River and certain of its tributary streams and waterways supplemented the Sacramento River Flood Control Project by providing flood protection to major cities along the river system and to agricultural land. The Reclamation Board was the sponsor of this project.

Sacramento River, Chico Landing to Red Bluff Bank Protection Project. In 1958, Congress authorized the Chico Landing to Red Bluff Project as an extension and modification of the Sacramento River Flood Control Project to help stabilize the main river channel, to alleviate bank erosion problems, and to reduce downstream maintenance dredging. Continued construction was authorized in 1976. This project was not completed; it has been inactive since 1985.

Sacramento River Bank Protection Project. The Sacramento River Bank Protection Project was authorized by Congress to maintain the integrity of the Sacramento River Flood Control Project.

The Sacramento River Bank Protection Project was originally authorized in 1960 in Public Law 86-645, and re-authorized in subsequent acts of Congress. The scope of the project was a long-range program of bank protection and levee setbacks to protect the existing levee system of the Sacramento River Flood Control Project. The Flood Control Act of 1960 authorized construction of the first phase of the project. The second phase of the project was authorized by the 1974 River Basin Monetary Act, the Further Continuing Appropriation Act of 1983 (which extended the authority into the Butte Basin), and the Water Resources Development Act of 1986 (which also authorized environmental mitigation for the first phase of the project). Recreational development was added as an additional purpose of the Bank Protection Project in 1964, pursuant to Section 207 of the 1962 Flood Control Act (Public Law 87-874). Authorized improvements under this purpose include boat launching ramps, day-use facilities, parking, and access improvements for public use of the river.

In 1983, Public Law 97-377 extended the authorized bank protection work area upstream to River Mile (RM) 194 at Chico Landing to allow bank protection in the reach where overflows east to the Butte Basin occur during high flows in the Sacramento River. A division of flows is necessary in this reach to prevent excess flows from entering the leveed portion of the river and thus threatening the integrity of the downstream levee system (see ***Butte Basin Plan of Flood Control*** below).

Mitigation of Environmental Impacts of Bank Protection Projects. During the course of bank protection work and emergency work, fish and wildlife habitat, in the form of riparian vegetation, may be removed. In addition, the resulting bank protection, emergency repair and associated maintenance activities usually preclude the natural re-establishment of the lost habitat. While no provision was included in 1960 in the authorization of the first phase of the Sacramento River Bank Protection Project for mitigating impacts, authorization for post-mitigation for first phase impacts was included in the Water Resources Development Act (WRDA) of 1986. Authorization of the second phase of the Bank Protection Project included environmental measures.

Mitigation for Bank Protection Project work to date has been attempted by these measures: acquisition of environmental easements and land purchased in fee by The Reclamation Board; use of rock fill to build eroding banks outward where rock revetment is to be installed, thereby avoiding cutting back into berms occupied by woody riparian vegetation; and construction of low berms to provide areas for re-growth of riparian vegetation. Measures to minimize project impacts are: minimization of bank protection site length; minimization of rock extent (lowered elevation); and waterside construction rather than landside. In addition, avoiding certain sites altogether has eliminated impacts to the environment.

Environmental easements were purchased from willing sellers to mitigate for the second phase of the Bank Protection Project. These easements allow for the preservation and protection of wildlife habitat. The lands were purchased to mitigate for first and second phases of the Bank Protection Project. The mitigation areas are summarized in Table 2-1.

TABLE 2-1
SACRAMENTO RIVER BANK PROTECTION PROJECT MITIGATION

Type of Mitigation Area	Location	Number of Acres
Environmental Parcels (easements) -- Second Phase, SRBPP	various (67), Sacramento River	426.99
Mitigation Lands		
First Phase, SRBPP	RM 191.6R, Sacramento River	107
First Phase, SRBPP	RM 164.2L, Sacramento River	42.1
Contracts 41B, 42	32.0R, Sacramento River; 23.8 & 22.4L, Steamboat Slough	1.5
Cache Slough/Yolo Bypass	Cache Slough/Yolo Bypass	176
Second Phase/Butte Basin Reach	RM 190L (approx)	94
	Total	847.59

The easements purchased between Collinsville and Chico Landing are located between the waterside levee toe and the river on the waterside berms. Easements purchased above Chico Landing were acquired as additional strips of land along the top of the rock riprap. The easements are inspected twice yearly by DWR's Flood Project Inspection Section. Inspectors look for encroachments or unauthorized activity in these areas.

In 1987, the FWS completed an evaluation of selected bank protection sites (Units 27-36). This evaluation determined that the environmental measure of rock fill, used to help protect berm areas, was costly and failed to ensure preservation of riverbank wildlife habitat. The purchase of environmental easements was also determined to be costly and only partially successful. The FWS decided that the major problem and habitat-limiting factor at most sites was the overuse of fire, herbicides, and discing by landowners and reclamation districts to eliminate vegetative cover. FWS made several recommendations for improving the success of mitigation work.

In 1991, the FWS completed a second evaluation of the effectiveness of mitigation measures employed under the Bank Protection Project. These measures were land acquisition, experimental artificial bank swallow nesting habitat, and experimental fishery mitigation structures. Rock fill was not evaluated due to a lack of information regarding site use. This evaluation found that while replanting efforts were successful, lands acquired remained unchanged since the time of their purchase. In addition, the bank swallow and fishery mitigation structures, which were experimental, were unsuccessful in replacing fully the habitat values lost by conversion of natural banks to rock revetment.

Butte Basin Plan of Flood Control. Prior to construction of levees, dams, and reservoirs in the Sacramento Valley, floods overflowed the Sacramento River into six natural overflow basins located adjacent to the main channel. At the north end of the valley, floods overflowed to the west into the Colusa Basin and to the east into the Butte Basin. Construction of levees on the west bank cut off flood flows into the Colusa Basin, and changed the amount of flow into the Butte Basin.

The Sacramento River Flood Control Project was originally designed so that flows in the river at the beginning of the project levees would not exceed 150,000 cfs; the rest of the flows would overflow into the Butte Basin. The Butte Basin now effectively acts as a huge reservoir to detain flood flows, releasing them into the Sutter Bypass at the south end.

The Federal flood control project envisioned in the 1950's included elements in the Butte Basin overflow area. Included were an extension of the east bank levee upstream to Chico Landing, an overflow structure, and a leveed bypass through the Butte Basin to the Butte Sink. These project elements were deferred due to economic and environmental issues. They would have reduced flooding of agricultural lands but also would have significantly reduced the attenuation of flood flows currently provided by the Butte Basin. The Corps, through the Sacramento River Bank Protection Project, contributed to channel stabilization. The Reclamation Board and DWR, through ordered actions and construction of bank stabilization and flood relief structures within the Butte Basin Plan of Flood Control, further addressed the need to maintain the proper split of flows between the river and the Butte Basin.

In a 1964 report, The Reclamation Board identified actions to ensure proper flow splits. The Board subsequently ordered that a number of levees constructed by local landowners be lowered in elevation to ensure that flows into the Butte Basin not be impeded. The Board also established maximum elevations for existing or future structures that could impede flows.

A 1986 report documents The Reclamation Board-approved Plan of Flood Control for the Butte Basin Overflow Area. The Corps participated in the bank stabilization element through the Sacramento River Bank Protection Project. DWR (through special legislation) constructed the two flood relief structures. DWR maintains the project to design standards, and the land use controls previously established by The Reclamation Board.

Sacramento River Flood Control System Evaluation. In 1986, Congress provided funding for the Corps to evaluate the condition of the Sacramento River Flood Control Project. The evaluation was performed in five phases with substantial participation by DWR, with each phase covering a distinct geographical region of the river. Remediation of the flood control project to prior design standards to ensure the integrity of portions of the system is being carried out by the Corps and The Reclamation Board based on these evaluations. The scopes and status of the five phases are discussed in Appendix G.

American River Flood Control Project. The American River Watershed Investigation Feasibility Report and Environmental Impact Statement were completed after the 1986 floods. Alternative flood damage reduction measures were proposed. In WRDA 1996, Congress authorized construction of elements that are common to each of the alternative measures. These elements are: stabilizing 24 miles of existing levees along the lower American River; raising and strengthening about 12 miles of levees along the east side of the Sacramento River; and implementing a telemetered in-flow gage system and emergency flood warning system. Construction of the slurry wall in the American River levee system began in 1998. Final elements of the project are still being debated. Some stakeholders support additional storage upstream, while others support modifications to Folsom Dam and levees downstream to increase the objective release. A final solution cannot be reached until there is a broader consensus among the stakeholders.

The San Joaquin River Flood Management System

Flood management on the San Joaquin River began in the 1910's with dredging of hydraulic mining sediment and debris. Major construction work followed, starting in the late 1930's. By the end of the 1970's, a system of dams, levees, and bypasses was in place on the San Joaquin River and its tributaries. Following is a history of the development of the flood management system in the San Joaquin River basin. Detailed descriptions of the system are provided in Chapter 3 of the Post Flood Assessment; a summary is provided in Chapter 4 of this report.

Prior to development in the Central Valley, the San Joaquin River system was characterized by a high bed load of sediment with high flow variation and frequent channel meandering and bank overtopping. The system has been subject to both rainfall and snowmelt runoff, and has a history of frequent major floods from a surplus of either or both. The development and operation of major dams and reservoirs have modified flow conditions and increased low flows during the summer months from the Merced River downstream.

Hydraulic mining in the Sierra foothills in the late nineteenth century contributed significantly to the production and transport of sediment in the San Joaquin River. To remove the sediment, large suction dredges were used along the mainstem San Joaquin River in 1913 and 1914. This dredging was prompted by the River and Harbor Act of 1910.

Construction of a major flood control project began on the San Joaquin River system in 1937, when Congress authorized the construction of Friant Dam on the upper San Joaquin River. The project was completed in 1949, after being delayed by World War II. In the Flood Control Act of 1944, Congress authorized construction of the Lower San Joaquin River and Tributaries Project (and it authorized similar work on the Sacramento River). The Lower San Joaquin River and Tributaries Project involved construction of levees on the San Joaquin River downstream of the Merced River, and on the Stanislaus River, Old River, Paradise Cut, and French Camp Slough. The project also included construction of New Hogan Dam on the Calaveras River, New Melones Dam on the Stanislaus River, and New Don Pedro Dam on the Tuolumne River. Construction of the project began in 1956, and is complete.

Under the authorized plan for the portion of the project upstream from Merced River, the State was to provide flowage easements in areas subject to flooding. However, in lieu of flowage easements, the State chose to construct a bypass system consisting of levees and channel modifications. These modifications were coordinated with the Federal government to insure the effectiveness of the overall project. Construction of the original State system was initiated in 1959 and completed in 1966. Operation and maintenance of the completed State bypass features of the project are accomplished by the Lower San Joaquin Levee District.

In 1962 and 1963, Congress authorized construction of Buchanan and Hidden Dams on the Chowchilla and Fresno Rivers, respectively, and authorized participation in funding the construction of New Exchequer Dam on the Merced River, completed in 1968. Also during these two years, Terminus Dam was constructed on the St. Johns River and New Hogan Dam was completed.

Construction of New Don Pedro Dam was completed in 1971. Construction of Hidden Dam and Buchanan Dam was completed in 1975. New Melones Dam was the last dam to be constructed and was completed in 1979.